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TITLE: BEAM-PROFILE MEASUREMENT ON THE MAGNETOELASTIC MICROSCOPE

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BEAM PROFILE MEASUREMENT ON THE MAGNETOELASTIC MICROSCOPE

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A need exists in the Inertial Confinement Fusion program for the nondestructive inspection of opaque, multilayer targets. An acoustic microscope operated at microwave frequencies would have sufficient temporal and spatial resolution to allow such inspection, but an acoustic lens capable of examining a complex spherical shape is not currently available. In order to examine an object as complex as an inertial fusion target, it would be necessary to vary the depth of focus to conform to the region of interest as the target is scanned laterally.

The design and computer modeling of a magnetoelastic lens capable of electronic focusing has been described in a previous paper.[1] The focus of this lens is electrically controllable because the acoustic field within it is ultimately shaped by the internal magnetic field distribution. To prove the principle of operation, a lens was assembled consisting of a rod placed in a uniform magnetic field; although not in any sense an optimum design, this represented the simplest case to fabricate, to computer model, and to analyze.

A cross-sectional view of this proof-of-principle design is shown in Figure 1. The dc bias magnetic field was provided by five Alnico VIII ring magnets, 4.93-cm o.d. x 2.41-cm i.d. x 0.64-cm thick. Iron pole pieces were used as end caps, with a 0.79-cm-diam access port drilled through and centered on the axis. A brass holder (not shown) supported a

1.0-cm-long by 0.3-cm-diam yttrium iron garnet (YIG) rod in line with the field axis and midway between the pole faces. The field was measured without the YIG rod in place and found to be 1000 Gauss. Variation of the field over the sample dimensions were ± 25 Gauss in the axial direction and ± 10 Gauss in the radial direction. Surrounding the ring magnets we placed a solenoid which allowed us to vary the field from 800 to 1250 Gauss by the application of a dc current of -400 to +400 mamp.

The specimen stage of the microscope consisted of a plexiglass probe on which was mounted a 200-μm-diam BeCu sphere. The force applied to the YIG face by the BeCu sphere, monitored by a Snaevitz FRA-G-100 force transducer, was usually in the range of 0.5 to 1.5 grams.

A gated RF pulse at 935 MHz was introduced to the YIG via a grounded feed wire. The amplitude of the first echo was recorded as the contact position between the YIG and the BeCu sphere was moved along the face. In this way the microscope was used to take a profile of its own amplitude distribution.

To understand this, consider that the contact absorbs and/or scatters the acoustic energy over the length of contact Δx, such that this energy is not detected upon reflection. If the amplitude distribution is initially given by $A(x)$, the amplitude detected when the probe makes contact, $F(x)$, is

$$F(x) = \int A(x)dx - A(x)\Delta x,$$

but $\int A(x)dx = K$, the quiescent signal in absence of the contact, so that

$$A(x) = \frac{K - F(x)}{\Delta x} .$$

This implies the amplitude distribution is the inverse of the measured absorption distribution times a scale factor.

The measured amplitude distribution is shown in Figure 2 and compared with the amplitude calculated from the magnetoelastic optics model. The agreement is good, with a measured half-power width of 280 μm as against a 250-μm width expected. The launch surface position, as indicated by the delay time of the first echo, was varied over 1 mm by changing the magnetic bias. Only a very slight beam width change was observed indicating that the design tends to produce collimation rather than strong focusing. This also was predicted by the magnetoelastic optics model.

Using a 1.5-mm-diam BeCu sphere with a ~40-μm-thick gold coating, a second echo from the gold/BeCu boundary was observed. Converting the measured delay time to thickness yielded a gold layer thickness of 33 ±2.5 μm. Signal-to-noise was poor, ~ 10 db, due to the relatively small reflection area compared to the beam size.

The proof-of-principle magnetoelastic lens has been shown to behave much as expected. Calibration of its behavior has been achieved in a relatively simple and repeatable way. The relatively good agreement with the magnetoelastic optics model gives rise to the hope that focusing of the internal field will ultimately give rise to diffraction limited operation; that is, to about 4 μm for shear wave operation at 1.0 GHz.

1. W. L. Bongianni, J. Vac. Sci. Technol., Vol. 18, No. 3, pp 1214-1217, April 1981.

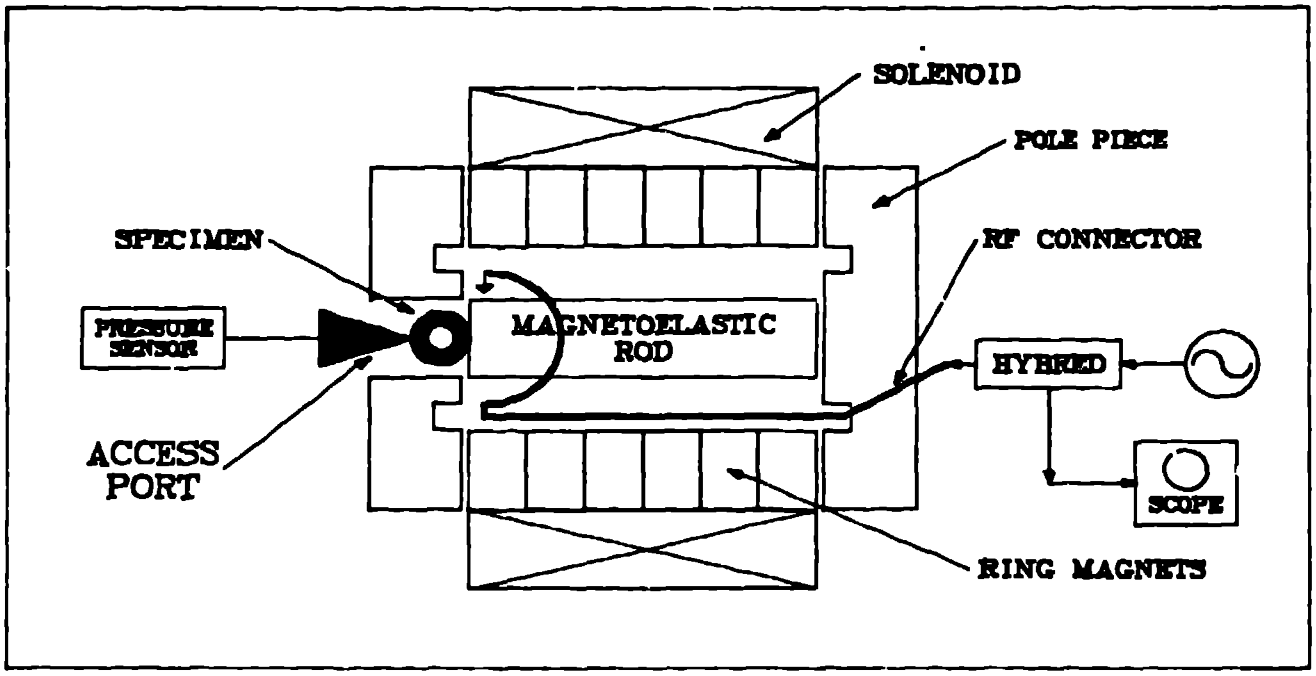

Figure 1. Magnetoelastic microscope

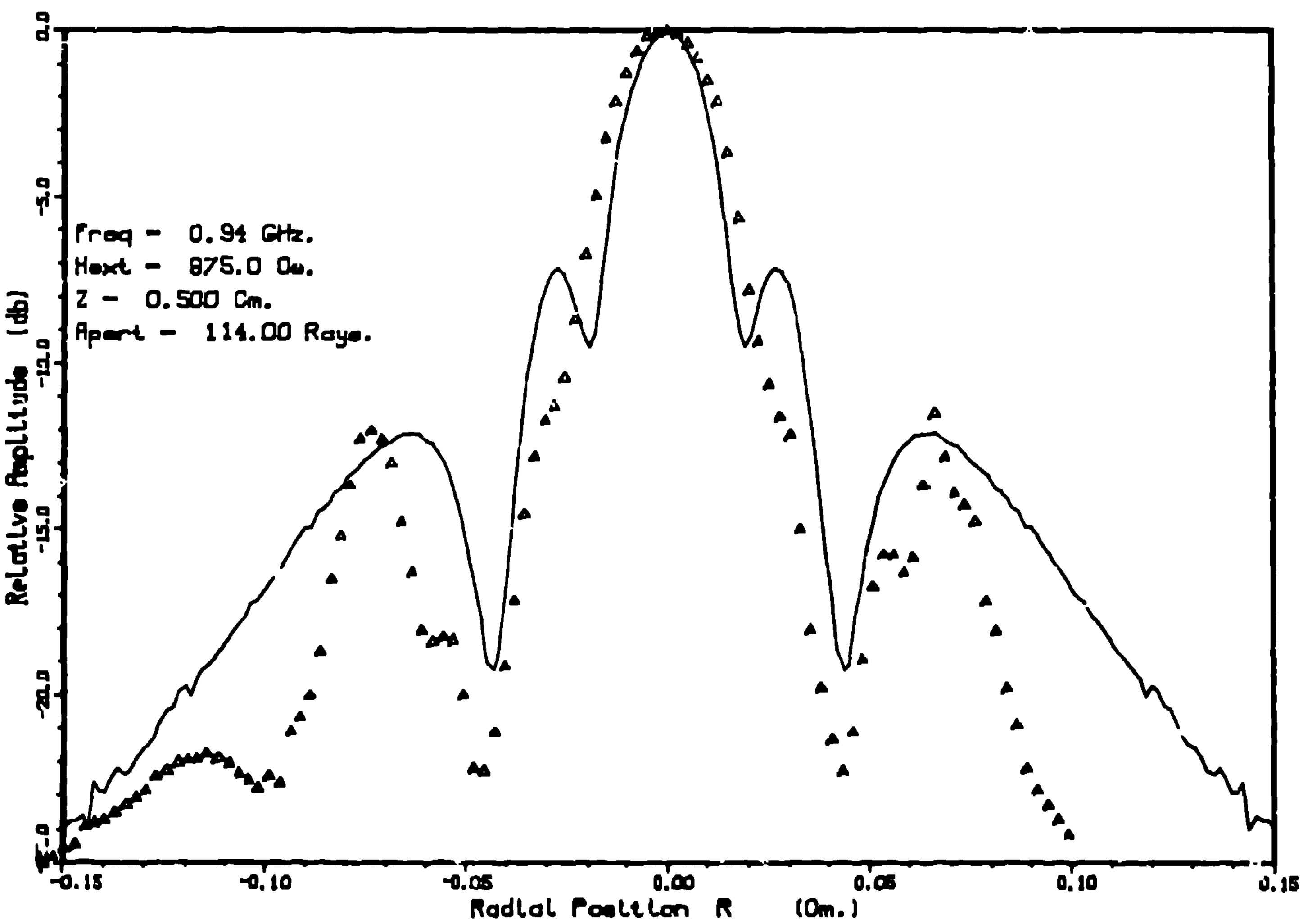

Figure 2. Magnetoelastic beam profile